



Creating a

*Never doubt that a small group of thoughtful, committed citizens can change the world.
Indeed it's the only thing that ever has.*

- Margaret Mead,
Anthropologist, 1958

Green Design Process

GREEN BUILDING FOR PENNSYLVANIA'S FUTURE

CONTENTS

- Green Design and Construction Process
- Design Optimization
- Construction Documents and Specifications
- Bidding and Construction
- Building Commissioning
- Operations and Maintenance

The Green Design & Construction Process

Traditionally the design process has been taught and practiced as a linear progression from design to construction to occupancy. Most decisions are driven by cost, time and the quality of the product desired. When planning high performance green buildings, decision makers need to be aware of the connections between environmental stewardship and the life cycle cost implications of long term investments in building stock.

High performance green building design should be a comprehensive, inclusive process that rewards people with resource efficiency, pollution avoidance and project cost reduction. The traditional design process is linear and compartmentalized, with upstream decisions severely impacting downstream building performance. The current system wherein design professionals and consultants are paid a percentage of the project cost provides little incentive to work creatively to reduce project costs while keeping design standards high. Conversely, there is little reward for those who work diligently to create extraordinarily resource efficient, attractive and productive working and living environments if there is not equitable compensation.

There is growing evidence that the economic return on more productive human work environments will quickly pay for the extra investment made in high performance design. The pressure to accept low bid contracts and minimal quality standards for materials and construction techniques is usually evaluated against first cost criteria, seldom considering the long-term benefits of quality, people-friendly, durable

buildings. Too often this results in a "pay me now or pay me later" scenario in which the tax payer pays for both. At the same time, the Commonwealth is saddled with a growing inventory of prematurely obsolete and costly buildings which stress our economic and natural resource reserves.

In response to this and other issues, Gov. Ridge established the 21st Century Environment Commission and has begun the Governor's Green Government Council. The purpose of these programs and the proposals they generate is to further align environmental stewardship with economic opportunity across all twenty-seven state agencies. There are already serious initiatives within several agencies and departments to shift toward sustainable design and development, and green busi-

"Solving the environmental issues of the 21st century will require new approaches, not only in the measurement of progress,

but also in the means of achieving it. We must improve the way we do business together by promoting teamwork instead of accepting confrontation."

ness practices. These initiatives herald a change in the regulatory climate in the Commonwealth that will ultimately be manifest in the private sector and state government institutions alike. The economic force and purchasing power of the Commonwealth and its agents will provide direction for the new paradigm of sustainable design and development.

Final Report of the
Pennsylvania 21st Century
Environment Commission

process

environmentally responsive *design process*

PREDESIGN

- Assemble Green Team
- Develop Green Vision
- Establish Project Goals
- Establish Green Design Criteria
- Set Priorities
- Develop Performance Based Building Program
- Establish Energy and Lighting Budget
- Develop Partnering Strategies
- Develop Project Schedule
- Review Laws and Standards
- Conduct Research

DESIGN

- Confirm Green Design Criteria
- Develop Green Solutions
- Evaluate Green Solutions
- Check Cost
- Integrate Systems
- Refine Green Solutions
- Check Cost
- Document Green Materials and Systems
- Verify Material Test Data

CONSTRUCTION

- Verify Submittals for Green Products & Systems
- Commission the Systems

OCCUPANCY

- Regularly Confirm System Performance
- Perform Maintenance
- Conduct Post-Occupancy Evaluation

Based on:

Sustainable Building Technical Manual,
Public Technology, Inc., 1996.

Generally, the high performance green building design process involves the following steps:

- Team building and goal setting
- Design optimization
- Construction documents and specifications
- Bidding and construction
- Commissioning
- Operation and maintenance

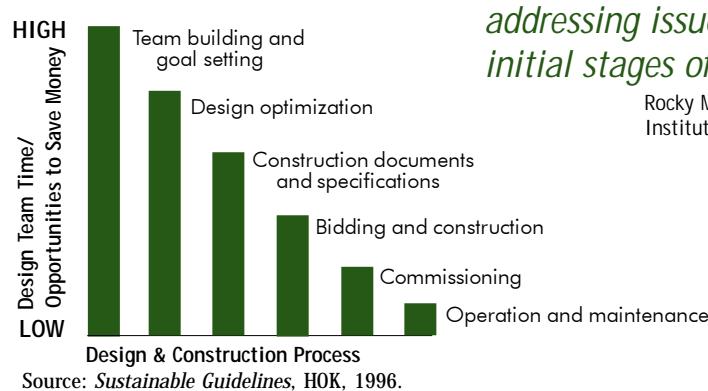
It is important to note that the greatest opportunities for project success rest in the initial stages of team building and goal setting. It is usually more costly and often less desirable to make small changes, let alone significant revisions, to projects in the latter stages of construction. This is why green building is often referred to as a "front end loaded, human energy intensive exercise."

In order to create high performance green buildings, decision makers must be willing to engage this process. Sufficient time must be allowed for a comprehensive planning process to take place. Stakeholders must be encouraged to evaluate the overall benefits of high performance, green de-

sign ideas in an atmosphere conducive to exploration and creative solutions. The goal of reducing project costs while increasing energy and resource efficiency must be viewed as a viable way of achieving cost effective buildings. The benefits of investing in the initial stages of design must manifest themselves in the end product. This includes a fee structure or system of compensation that rewards solutions that reduce project costs. The indicators of whether or not this goal has been met will vary with such things as building type, the purpose of the project, financing strategies and the expectations of the stakeholders. In all cases, however, the success with which a high performance, green building has been achieved can be measured by how well the interests of the owner, the occupants and the natural environment have been balanced. Properly done, an equitable balance between these three interests will be reflected in a project that is functionally superior and aesthetically pleasing, environmentally sensitive and economically sound.

"It is much easier and cheaper to maximize the benefits of green planning and design by addressing issues in the initial stages of a project."

Rocky Mountain Institute, 1998



Design Optimization

Design optimization is the process by which the performance and cost effectiveness of all aspects of a project are refined and maximized. Traditionally, most emphasis has been placed on optimizing design choices based only on budget or time considerations. Very often single components or finishes are added or deleted to meet time or budget constraints without evaluating their impact on total building performance. High performance green buildings are optimized by extending this process to include entire building systems, their relationship to one another and what must be done to balance the impact of each system against long term stewardship and building operation.

After setting goals, criteria and priorities, the team needs a clear understanding of what it will take to optimize all aspects of the project. The design optimization process looks at the systems and products as the building is being designed to ensure that the intended goals are being reached and exceeded.

One purpose of design optimization is to scrutinize the large, over arching goals set at the beginning of the project to see if the effort is on track. Another is to take advantage of each additional opportunity that presents itself as the project evolves. Often, especially in the case of large, complex projects, the choices and issues involved can be overwhelming. Matrices that list green criteria such as performance levels or other information can be created to help evaluate one system or product against another.

Computer modeling has become an important part of deciphering what collections of choices or systems should be integrated to achieve the best possible building performance. Modeling

programs analyze huge amounts of information including weather, site conditions, building context, user profiles and other project variables. They also model over a period of time -- something that would be incredibly time consuming if done by hand.

Basic design goals such as minimizing energy consumption or maximizing daylight cannot be done without understanding the impact of integrated systems such as window glazing systems, the thermal envelope, mechanical system integration, floor plate proportions and other systems. Data from a program like DOE 2 can give the design team a factual basis by which to make decisions.

Although many computer modeling programs can give data involving operating expenses and potential money savings, they are strongest at

"When a series of linked efficiency technologies are implemented in concert with each other, in the right sequence and manner and proportions,

there is a new economic benefit to be reaped from the whole that did not exist with the separate technological parts."

comparing the relative performance of different systems and materials. Once armed with this rational decision making tool, team consensus should be easier and the production of construction documents a more efficient, profitable process.

Other aspects of the design must be optimized in concert with building systems. Functional and programmatic issues such as efficient use of space, shared services, flexibility, adaptability and access are all project considerations worthy of optimization. Build-

*Home Energy Brief,
RMI, 1994*

process

design optimization checklist

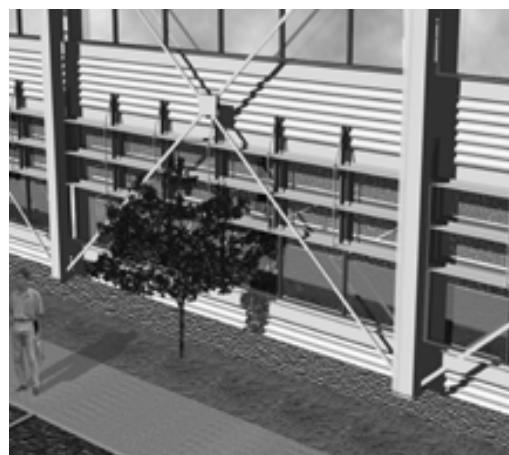
- Revisit the original goals of the green design team to see whether the overall intentions of the project are intact.
- Compare the project against existing rating systems such as the U.S. Green Building Council's LEED program.
- Scrutinize each of the building and site components to ensure natural systems for energy conservation, lighting, ventilation, and passive heating and cooling are maximized before mechanical systems are engaged.
- Confirm the appropriateness and integration logic of the buildings primary systems.
- Evaluate the impact of the design on the site and its larger context. Include environmental impact in the life cycle cost analysis of building design and construction options.
- Utilize building systems modeling software, design tools, and the experience of the design team to optimize design.
- Include all members of the design team when making design decisions.
- Revisit the original project goals frequently to ensure the project goals are being met, and the budget and project cost benefits are being evaluated based on life cycle cost criteria. Issue a statement of design intent to document all design assumptions.
- Include commissioning, operation and maintenance in the design optimization process.

ing systems optimization extends to the coordination of structural systems with assembly and disassembly considerations, fabrication, material packaging, delivery and building component construction strategies. Building zoning solutions, control strategies and the distribution of mechanical equipment for optimum performance and ease of access and maintenance are also important.

The efficient use of materials is another category of optimization. Incorporating sizes, shapes and proportions that minimize waste and make the most of a material's intended use contributes to design optimization. Materials that lend themselves to reuse and recycling, and which reduce the need for packaging and handling, are preferred to those which do not. Creative design using standard shapes and sizes are more apt to adapt to changing technologies, improved building systems and industry innovations. Extensive use of "one of a kind" building components, custom features or hard to replace items may all eventually contribute to premature obsolescence and increased maintenance costs.

A better design can often be achieved by limiting the number of materials and building systems involved. Design optimization is accomplished by eliminating unnecessary ornament or detail. Material selections that minimize maintenance, cleaning or frequent replacement represent another form of design optimization.

The task of design optimization varies with the project type and the goals that are set forth at the beginning of the design process. Decision makers must encourage project team members to vigorously undertake the optimization process. Team members must be capable and willing to evaluate each optimization suggestion or opportunity as it presents itself throughout the design and construction process. A commitment to continuous refinement and design optimization is the best possible insurance of a cost effective, high performance green building.



This computer rendering was done to illustrate light shelf configurations that were modeled with the DOE 2 energy simulation program.

Illustration: Gardner+Pope Architects

Construction Documents & Specifications

The art of recording how a building is to be constructed is as old as the profession of architecture itself. And, while much has changed about how and why we build, we still depend on drawings and specifications, collectively known as construction documents, to record the building process.

The process of creating high performance green buildings begins with a statement of design intent. The statement of intent should clearly set forth the goals of the project. It should recognize the intended use of the project and, to the greatest extent possible, any future uses that can be envisioned. A well written statement of design intent is usually the product of effective green team building and goal setting and includes a description of how systems are to perform. These goals can be such things as creating an energy and resource efficient structure, or a strategy to achieve maximum flexibility and adaptation to changing technologies, building systems and components. Committing this statement to writing is a critical first step to ensuring that the project participants agree upon the goals of the project and the priority each has been given. As the project proceeds through programming and construction documents, it is necessary to revisit and update the statement of design intent to ensure that the goals of the project remain intact.

Creation of a performance program is the next step in creating high performance green buildings. The performance program is built upon the goals established by the statement of design intent. Its purpose is to document the overall strategy for integrating the parameters of the project. These typically include such things as budgets, site utilization, space planning, integrated building systems, oc-

cupancy issues and other specific needs or goals of the project. The performance program also sets forth the target limits for many of these systems. For instance, the performance program of a high performance green building may require the maximum utilization of daylighting and the attendant goal of .75 watts per square foot maximum of electric lighting. Performance program goals can also include such considerations as the elimination of volatile organic compounds (VOCs) and achieving superior interior air quality.

Today, decision makers can employ the use of building rating systems to assist them in writing performance programs. The Leadership in Energy and Environmental Design (LEED) building rating system, developed by

“Specifications prescribe a project’s standards in such matters as selection and quality of materials, installation procedures, administrative protocols, and site controls.”

“When a project includes unusual or innovative practices or requirements, it is especially important to have well-defined specs.”

*Green Development,
RMI, 1998.*

the U.S. Green Building Council, is one. It is a comprehensive overview of energy, resource and occupant issues that pertain to high performance green building design. It provides, at the very least, a good format for establishing a more complete, project specific performance program. Using the LEED system carries the added advantage of being certified as a rated building by the U.S. Green Building Council.

process

documents/specifications

checklist

- Use the design documentation process to establish a clear statement of design intent. Continuously refer to the statement of design intent throughout the documentation, construction and commissioning processes.
- Utilize the LEED building rating system or other green design checklists as a guide for setting and evaluating design intent and project goals.
- Utilize the numerous green design and material information documents now available in Construction Specifiers Institute (CSI) format.
- Include construction waste management, commissioning, and operation and maintenance information in the construction documents.
- Develop building system integration drawings that illustrate how various building systems and components relate to each other. Support these drawings with the specifications.
- Feature the high performance green building operation and system parameters in the performance program. Establish both quantitative and qualitative goals that will result in high operating efficiencies and maximum occupant comfort and performance.
- Emphasize the importance of a comprehensive and efficient design documentation process to the entire project team
- Use the commissioning process to verify construction documents. Update project documents when changes occur. Keep all records current.
- Use the project documents as a base for a comprehensive set of

Design documentation usually concludes with construction drawings and specifications, and the addenda and change orders that typically occur during construction and commissioning. Collectively they are known as construction documents. They represent the methodology through which the design intent of the decision makers is recorded and, ultimately, achieved. Most design firms utilize the organizational format set forth by the Construction Specifiers Institute (CSI). And while there continues to be a degree of customizing in office practice, the CSI system facilitates the presentation of information in a clear, standardized manner. It is the standard to which most new green products and building component manufacturers subscribe. And, because the sixteen-division CSI format is recognized as the industry standard, it is the mechanism through which new products and processes are incorporated, and the vehicle through which the creativity and innovation of the design process are implemented. At first glance, this is a very convenient system, weighted by the need to have all things in order should the project become involved in litigation. At the same time, there are several issues that need to be addressed in the construction documents of high performance green buildings that are not covered in the conventional CSI format.

The first is a growing need to recognize the importance of integrated building systems. This necessitates the addition of "integrated systems drawings" and supporting documents to the set of project documents. Integrated systems drawings illustrate how parts or aspects of building systems and components relate to and impact each other. Most simply, these may be draw-

ings that illustrate the relationship of a raised-floor air distribution system to the wiring and ductwork that are contained in the same space. Or, it could be a drawing that relates the connections of a structural system to the supports for exposed ductwork or wiring racks. If one were to rigidly adhere to the CSI format, these systems would be on separate drawings, or there would not be sufficient information about the associated work to fully understand how the systems relate. In high performance green buildings, the addition of integrated systems drawings adds clarity and efficiency to the design and documentation of the building.

Similar scrutiny must be given to specifications. Specifications work hand in hand with construction drawings to provide information which cannot be illustrated, or which needs special emphasis on procedure or building products and components. Specifications for high performance green buildings must work to overcome the separation of work or intent that may be a product of industry standard specification format. Also, other important high performance green building issues, such as construction waste management and building commissioning must be introduced in specifications.

Today's decision makers and project managers must be knowledgeable about the potentials and limitations of project documentation in creating high performance buildings. And, as key members of a high performance green building team, they must take an active role in ensuring that all project participants contribute to the success of a comprehensive, cost effective and efficient project documentation process.

Bidding & Construction

Bidding and construction are traditionally considered together in conventional construction. In creating high performance green buildings, however, each takes on increased importance if the goals of the project are to remain intact. A team approach to designing and building high performance projects includes bidding and negotiating as a much more integral part of the project flow.

One of the advantages of the team approach is the opportunity for ongoing budget and cost feedback in concert with investigating project options as they occur. Team members familiar with the project and its goals from the beginning can put traditional budget and time based concerns in a more comprehensive decision making matrix.

Another advantage to high performance green building by team is that vendors, suppliers, subcontractors and others who become involved during bidding and negotiating can be educated by a unified team knowledgeable about the project as a whole. The efficiencies and time saved in this scenario may offset many of the perceived savings usually associated with competitive bidding while still working toward quality building. Cost and time savings are even more probable if this logic is extended to the latter stages of construction because change orders and unforeseen complications due to lack of communication can be reduced.

In conventional competitive bidding situations, it is the responsibility of the project team to educate all participants to the goals of the project. New materials and techniques may be misunderstood or made unnecessarily expensive by vendors who do not understand exactly what is desired by the

project team. Consequently, team members may have to plan education and orientation sessions into the bidding and negotiating sessions to ensure reasonable costs and scheduling expectations.

Conversely, the project team must anticipate the likelihood that contractors and subcontractors will pressure the project for substitutions of materials and practices that might be more familiar. A well educated and grounded design team is invaluable in this situation. Reasonable substitutions and allowances for acceptable construction practices must be made in light of the overall goals of the project.

The statement of design intent

"Construction is the stage in which all of the visions, planning and designs for a development are brought to fruition....This is an exciting, but also a high-risk stage of development, and 'doing it green' can be seen as adding one more element of risk or challenge."

Even the best-laid plans of a green designer can fail if construction is done on an uniformed or irresponsible manner."

will help to make the team goals clear to all who are involved in the project. The greater the understanding of these goals and to what extent they are conveyed to the prospective contractors and subcontractors will determine the degree to which the original goals of the high performance design remain intact. In order for this to happen, the design team is obliged to establish an atmosphere within which information is shared and questions and recommendations are encouraged.

Primer on Sustainable Building
RMI, 1994

process

bidding/construction checklist

- Closely consider the merits of design and construction by team as opposed to the conventional, linear bidding and construction process.
- Be aware of the need to inform and educate contractors, vendors and suppliers about the goals of the project.
- Use job meetings, project records, memos, and other project communication methods to educate and remind construction parties about the high performance, green building aspects of the project.
- Include periodic reviews of the statement of design intent in the normal course of job meetings and associated correspondence.
- Maintain accurate "as-built" drawings and other records that will assist in the commissioning and ongoing operation and maintenance of the completed project.
- Scrutinize requests for alternates to ensure compliance with all goals of the project, including interior air quality and systems integration.
- Ensure compliance with special project requirements such as offgassing volatile finishes, supplying temporary ventilation and isolating occupied areas during construction.
- Increase the awareness of worker protection and the long term impact on workers health of toxic, volatile and otherwise dangerous building materials and practices.
- Carefully review submittals to maintain the goals and high performance standards set in the statement of design intent.

The construction of high performance green buildings should be typified by the physical attributes and qualities described herein. Ideally, contractors should benefit from savings in materials and insurance rates inherent in practicing construction waste management and on-site recycling. The pursuit of integrated systems should result in simpler construction without sacrificing the aesthetic and utility inherent in good design. Material delivery, construction sequencing and related time and schedule sensitive issues should be less problematic in a project that has been designed by team and bid by interested and educated individuals. The result is that the investment in the front end loaded, human energy intensive green building design

process should be justified by acceptable paybacks for high quality, resource and energy efficient buildings which are an asset to the owner and benefit to the user.

In constructing high performance green buildings, special attention is given to maintaining total environmental quality on the construction site. This is particularly true when occupants are present during renovation or in close proximity to new construction. In addition, any extra precautions taken to safeguard the natural environment and undisturbed areas of a building site are in keeping with environmentally sound building practices. Maintaining good environmental conditions during construction is essential to meeting the statement of design intent.

Building Commissioning

Building commissioning is the process of ensuring that building systems are designed, installed, functionally tested and capable of being operated and maintained according to the owner's operational needs. Building commissioning, or the process of bringing a building on-line, is a critical part of designing and building high performance green buildings. Building owners are spending more money on complex building systems than ever before. Yet, many find that they are not getting the specified level of performance. A DOE study of 60 commercial buildings found that more than half suffered from control problems. In addition, 40 percent had problems with HVAC equipment and one-third had sensors that were not operating properly. Fifteen percent of the buildings studied were missing specified equipment. Approximately one-quarter of them had energy management control systems, economizers or variable speed drives that did not function properly.

Commissioning ideally begins in the design phase of a project and extends at least one year into the initial occupancy of a new building. It is becoming increasingly common to extend the commissioning period to two or more years, depending on the building type and the degree of sophistication of the systems involved. However, it is never too late to commission an existing building. Existing equipment can be commissioned to ensure that it is operating as designed, and is being maintained within the recommendations set forth by the manufacturer. This, in turn, may benefit the owner by keeping compliance with warranty and guarantee requirements of the subject equipment or building systems. Own-

ing and operating a commercial building requires a substantial financial investment. Poor building performance almost certainly means that building owners are losing money. Excessive repair, reconfiguration and replacement costs, employee absenteeism, poor indoor air quality and frequent tenant turnover cost U.S. building owners millions of dollars each year. These costs are substantially higher when they occur in buildings with outdated or entrenched technology.

Commissioning cost can vary considerably from one project to another. Actual costs depend on the size and complexity of the project, and the extent and duration to which commissioning is pursued. Collectively these expenses represent a very small percentage of the overall project cost, yet the paybacks can be dramatic.

"The bottom line is that commissioning improves a building's value..."

systems that function properly use less energy, experience less down time, and require less maintenance, thereby saving money for building owners."

In a study of the cost effectiveness of commissioning 44 existing buildings, high rise offices and retail establishments had an average simple payback of 1.6 years. Medical institutions averaged 0.4 years, and computer facilities had a very attractive 0.3 year payback. Given these statistics and the additional benefits of preserving the overall value of the property being commissioned, it is easy to see

*Building Commissioning:
The Key to Quality Assurance*
US Department of Energy

process

building commissioning checklist

- *Include commissioning requirements in the performance program.*
- *Involve the eventual building operators, maintenance personnel and other appropriate stakeholders in the commissioning process.*
- *Involve the commissioning agent as one of the project development team members.*
- *Establish metrics for all specified equipment.*
- *Extend the commissioning plan beyond the conventional one year period to ensure consistent, reliable and verifiable building systems performance.*
- *Distribute the statement of design intent and the commissioning plan and appropriate documents (i.e. ASHRAE document, The HVAC Commissioning Process) to all team members prior to the design development phase of the work.*
- *Review the selected commissioning plan with the entire project development team. Note that while existing commissioning guides ensure a useful format, they may not fully recognize all goals set forth in green design and high performance buildings.*
- *Insist that accurate as built drawings and contract document revisions are maintained and distributed to all parties involved in commissioning.*
- *Retain the commissioning information as part of the permanent building records available to building operators and maintenance personnel.*

why a comprehensive building commissioning process is an important part of creating high performance green buildings.

An awareness of the importance of a comprehensive commissioning process can ensure optimum building system performance and the reduction in operating costs, increased energy conservation and pollution reduction associated with maximum efficiency. The project team may include requirements for using diagnostic tools and equipment such as fan doors to measure infiltration rates in the thermal envelope, or duct hoods with air quantity and velocity measuring devices to ensure proper performance of space condition-

ing and ventilation equipment. A more comprehensive commissioning process may include on-site monitoring equipment to measure radon, volatile organic compounds, carbon dioxide, carbon monoxide and other compounds depending on the nature of the building and its intended use.

Existing Building Operators and Managers Association (BOMA) and American Society of Heating, Refrigeration and Air Condition Engineers (ASHRAE) standards for commissioning buildings must be scrutinized for their effectiveness in ensuring long term acceptable building occupant conditions.

SYSTEMS THAT REQUIRE COMMISSIONING

Mechanical – Hot water heating, pumps, cooling tower, air handling equipment and controls

Plumbing – Service water heaters, pumps, tanks, compressors, controls

Electrical – Security systems, emergency generator systems, fire management systems, controls

Other – Sprinklers, elevators, audio/visual systems, controls

Operations & Maintenance

The return on investment made in high performance green buildings can only be realized if the design and construction process includes an integrated approach to operation and maintenance (O&M). The act of constructing buildings is usually undertaken with the assumption that our building stock will serve its intended purpose for an extended period of time. Our buildings are generally expected to perform as intended, and without incident, simply as a result of being "new." Yet we know that many new buildings do not perform as designed, and often are occupied with serious deficiencies in design, equipment and controls. Lack of performance is often compounded by incomplete or inadequate commissioning and staff who are not fully trained or otherwise capable of properly operating complex building systems (See *Commissioning*).

In high performance green buildings, proper operation and maintenance begins in the early planning stages with a commitment to cost effective, functional building systems, scheduled maintenance and operating procedures that recognize the need to meet equipment and systems manufacturers recommendations for O&M. It depends on an educated building staff and occupants who are aware of the O&M procedures the building management wants to incorporate.

Commitments to proper O&M begin outside the building with such goals as reducing the energy, pesticides and herbicides used to maintain the site. Integrated pest management (IPM) and less energy intensive landscaping schemes can be designed to make each more effective. O&M strategies that include energy and resource efficient landscaping and on-site composting of organic material are superior to those

that maintain large expanses of grass for no functional purpose. Using maintenance personnel to cut grass and blow leaves which are then discarded is not a good use of time or energy, compared to a landscape design that doesn't require either.

Astute building owners and managers are aware of the overall flow of waste and materials through the facility. Often recycling efforts can compliment composting and other strategies for reducing the organic waste stream. Food service operations should also be scrutinized for the potential to reduce waste flow while making the recycling and composting effort more effective.

"Consistent operations and preventative maintenance, including troubleshooting of building systems, safeguard the most positive and persistent effects of commissioning. Keeping buildings functioning properly, especially where indoor environments are directly linked to occupant safety and staff productivity,

is one of the best investments building owners can make."

*Manual on Building Commissioning,
US Department of Energy*

Maintaining a clean building also begins far away from the entrance ways. Good O&M design recognizes how soiling agents are tracked into a building and how these intrusions can be limited without using harsh chemicals. O&M protocol should include a well-designed cleaning regimen that results in both good hygiene and superior indoor air quality for human health. This is often one of the simplest and most cost effective procedures decision makers can institute.

process

operations/maintenance checklist

- Include O&M concerns and design criteria in the early planning stages. Facilitate efficient handling of the waste stream, design against tracking dirt in from the outdoors, etc.
- Include the cost of a comprehensive, effective O&M regimen in the project life cycle cost analysis and development budget.
- Strive to make connections between environmental stewardship and O&M procedures. For instance, could composting the organic waste stream of a high performance green building contribute to the health and vitality of living systems on the site?
- Adhere to manufacturers and equipment suppliers recommendations for proper O&M of building systems and components.
- Implement ecologically sensitive management and work plans for O&M. Clean for health as well as appearance.
- Make building users and occupants aware of the O&M goals and implementation strategies and the benefits that accrue to them if they support the plan.
- Adhere to all recommendations set forth in warranty and maintenance recommendations for building components and equipment.
- Include an environmentally responsible cleaning regimen that insures good interior air quality and occupant health.
- Educate all building occupants and other appropriate parties about the goals and benefits of the O&M program. Strive for maximum compliance.

Cleaning for health should include duct work and space conditioning equipment. This is especially true if coil surfaces, condensate pans, filter racks, humidifiers or other equipment that can harbor pathogens such as mold or other microflora are present.

High performance building operation recognizes the relationships between equipment performance, proper controls and building occupancy. Maintaining optimum conditions for comfort and maximum performance is dependent on distribution strategies, thermal zoning and controls that are understandable and easily adjusted. (See Building Systems) These conditions hold true for renovations to existing buildings, as well as for new construction. Ideally, resources spent properly operating and maintaining a facility are more cost effective than those expended reacting to complaints from building occupants and users. This is particularly true if the conditions deter-

iorate to where the profitability of the business enterprise is affected.

The growing awareness of the impact of the built environment on building occupants and users has given rise to the use of a post-occupancy evaluation, or POE, to assess the success of a project. A POE can also be used to evaluate the effectiveness of the commissioning phase of a building project, and can provide valuable insight into how ongoing operation and maintenance procedures can be made more efficient and cost effective.

Decision makers must be aware of the importance of operation and maintenance for optimum return on investment from high performance green buildings. Operation and maintenance occurs throughout the life of the building. Giving proper consideration to these issues in the early planning phases of the project will ensure a long and productive life for the building.

OPERATIONS & MAINTENANCE MANAGEMENT PRINCIPLES

1. Commit to people, education and communications.
2. Clean to protect health first, and appearance second.
3. Clean and maintain the building as a whole, not just the separate components.
4. Schedule routine maintenance.
5. Plan for accidents.
6. Minimize human exposure to harmful contaminants and cleaning residues.
7. Minimize chemical, particle and moisture residue when cleaning.
8. Ensure worker and occupant safety at all times.
9. Minimize the amount of pollutants entering the building, while maximizing the amount of pollutants extracted.
10. Dispose of cleaning waste in environmentally safe ways.

Steve Ashkin, Rochester Midland Corporation, 1995